

Teaching Physics with the Physics Suite

Edward F. Redish

TABLE of CONTENTS

Preface

Chapter 1 Introduction and Motivation

Introduction

Typical materials for a physics class

A new alternative: The Physics Suite

Motivation

Who are we teaching and why?

The growth of other sciences

The goals of physics for all

Are we already achieving these goals?

Figuring out what doesn't work and what we can do about it

Introducing Sagredo

Why Physics Education Research?

Knowledge as a community map

Building the community map for education

The impact on teaching of research on teaching and learning

Even good students get the physics blues.

I wouldn't have believed it if I hadn't seen it.

Some caveats

What this book is about

Chapter 2 Cognitive Principles and Guidelines for Instruction

The Cognitive Model

Models of memory

1. Working memory

2. Long-term memory

Cognitive resources for learning

1. Robust reasoning structures:

Common naïve conceptions

2. Modular reasoning structures:

Primitives and facets

3. Activating resources from everyday experience:

Situated cognition

Implications of the Cognitive Model for Instruction: Five foothold principles

1. The constructivism principle

2. The context principle

3. The change principle

4. The individuality principle

5. The social learning principle

Some General Instructional Methods Derived from the Cognitive Model

Cognitive Conflict

Bridging

Restricting the frame

Multiple representations

Rethinking the Goals of Physics Instruction

Extended Content Goals

Chapter 3 There's More than Content to a Physics Course: The Hidden Curriculum

A Second Cognitive Level

Expectations: Controlling Cognition

Expectations about learning

The structure of student expectations: The Hammer variables

Connecting to the real world

Metacognition: Thinking about thinking

Instructional techniques for improving metacognition

Affect: Motivation, Self-image, and Emotion

Motivation

Self-image

Emotion

Chapter 4 Extending our Assessments: Homework and Testing

Assessment and Evaluation

Giving Feedback to your Students

Homework

Getting Feedback from your Students	Models of the Classroom
Testing	The traditional instructor-centered environment
Designing exams	The active-engagement student-centered environment
Exams as formative feedback	The Population Considered: Calculus-Based Physics
Eight Types of Exam and Homework Questions	Characteristics of calculus-based physics students
Multiple-choice and short-answer questions	The hidden curriculum and problem solving
Multiple-choice multiple-response questions	Some Active-Engagement Student-Centered Curricula
Representation-translation questions	
Ranking tasks	
Context-based reasoning problems	Chapter 7 Lecture-Based Methods
Estimation problems	The Traditional Lecture
Qualitative questions	A more interactive approach to the traditional lecture
Essay questions	Demonstrations
	Peer Instruction / ConcepTests
Chapter 5 Evaluating our Instruction: Surveys	Interactive Lecture Demonstrations (ILDs)
Research-Based Surveys	Just-in-Time Teaching (JiTT)
Why use a research-based survey?	
Surveys and the goals of a class	
Delivering a survey in your class	
Understanding What a Survey Measures: Validity and Reliability	Chapter 8 Recitation and Laboratory-Based Methods
Validity	The Traditional Recitation
Reliability	A more interactive approach to the traditional recitation
Content Surveys	Helping your teaching assistants give better recitations
The FCI	Tutorials in Introductory Physics
The FMCE	The structure of Tutorials
The MBT	Tutorials often focus on important but subtle points.
Attitude Surveys	Should you post solutions to Tutorial pretests and homework?
The MPEX	What does it take to implement Tutorials?
MPEX Results	Tutorials produce substantially improved learning gains.
Analyzing the MPEX	Changing recitations to Tutorials doesn't hurt problem solving.
Getting improvements on the MPEX	Students need to get used to Tutorials.
The VASS	ABP Tutorials
Scientific dimension of the VASS	ABP Tutorials are mathematically and technologically oriented.
Cognitive dimensions of the VASS	Concept learning can be tied to the use of math.
The EBAPS	Cooperative-Problem Solving
	Cooperative Problem Solving (CPS) relies on context-rich problems.
Chapter 6 Instructional Implications: Some effective teaching methods	Group interactions play a critical role.
Introduction	
Research-Based Curricula	

The work of the group is better than the work of the best student in it
 Techniques for improving group interactions30
 The Traditional Laboratory
 Goals of the laboratory
 Often, less actually happens in traditional labs than we might hope.
 A more interactive approach to the traditional laboratory
 RealTime Physics
 RTP uses cognitive conflict and technology to build concepts.
 RTP relies on psychological calibration of technology.
 RTP labs are effective in building concepts.

Chapter 9 Workshop and Studio Methods

Physics by Inquiry
 In Pbl, students learn a few topics deeply.
 Students may need help in changing their expectations for Pbl.
 Evaluations of Pbl show it to be very effective.
 Workshop Physics
 Students in WP build their concepts using technology.
 WP is developed through and informed by education research.
 WP changes the frame in which students work.
 Evaluations of WP show it to be highly effective in building concepts.

Chapter 10 Using The Physics Suite

The Idea of The Physics Suite
 The Principles Behind The Physics Suite
 The Elements of The Physics Suite
 The Suite's narrative text: Understanding Physics
 Using the Suite in lab: RealTime Physics
 Using the Suite in lecture: Interactive Lecture Demonstrations
 Using the Suite in recitation sections: Tutorials
 Putting it all together: Workshop Physics
 Homework and exams: Problems and Questions

Evaluating instruction: The Action Research Kit
 Suite compatible elements:
 Peer Instruction, JITT, and Cooperative Problem Solving
 Using The Physics Suite in Different Environments6
 The role of room layout
 The role of facilitators
 Four Case Studies: Adopting and Adapting Suite Elements
 Using Suite elements at a small institution
 Gettysburg High School
 Pacific University
 Using Suite elements at a large institution
 The University of Illinois
 North Carolina State University

Conclusion

Bibliography

Appendix (on Resource CD)

- Sample Problems for Homework and Exams
 - Estimation Problems
 - Multiple-Choice and Short Answer Problems
 - Representation Translation Problems
 - Ranking Tasks
 - Open-Ended Reasoning Problems
 - Context-rich Reasoning Problems
 - Essay Questions
 - JiTT Problems (courtesy, Ellen Patterson)
- Action Research Kit
 - The Mathematical Modeling Conceptual Evaluation (MMCE)
 - The Vector Evaluation Test (VET)
 - Test of Understanding Graphics (TUG-K)
 - Force Concept Inventory (FCI)
 - Force-Motion Concept Evaluation (FMCE)
 - The Mechanics Baseline Test (MBT)
 - Energy Concept Survey (ECS)
 - Conceptual Survey of Electricity and Magnetism (CSEM)
 - The Electric Circuits Concept Evaluation (ECCE)
 - Rate and Potential Test, versions A and B (RAPT)
 - Wave Diagnostic Test (WDT)
 - Determining and Interpreting Resistive Electric Circuits Concept Test (DIRECT)
 - The Small Particle Model Assessment (SPMA)
 - The Measurement Uncertainty Quiz (MUQ)
 - Maryland Physics Expectations Survey (MPEX)
 - The Views about Science Survey (VASS)
- Bibliographic Resources
 - L. C. McDermott and E. F. Redish, "Resource Letter: PER-1: Physics Education Research," *Am. J. Phys.* 67, 755-767 (1999).
 - L. Jossem, "Resource Letter EPGA-1: The education of physics graduate assistants," *Am. J. Phys.* 68, 502-512 (2000)
 - Useful Books: A list of books that contain discussions of student learning, innovative teaching methods, and interesting problems.

- Reading List for a Graduate Seminar in Teaching College Physics for Physicists
- Reading List for a Graduate Seminar in Physics Education Research (courtesy, Diane Grayson)
- Other Resources
 - Guidelines and Heuristics: Summary of goals, principles, and commandments
 - Writing a Scientific Paper
- Resources for Computer Assisted Data Acquisition and Analysis
 - MBL information from Vernier
 - MBL information from Pasco
 - MBL information from Texas Instruments
 - Videopoint demonstration
 - Information on the Student Response System from Classtalk
 - WP Excel Tools
 - Information on the AAPT